

ATOLL RESEARCH BULLETIN

NO. 467

**A GENERAL BIOLOGICAL AND GEOLOGICAL SURVEY OF THE RIMS OF
PONDS IN THE MAJOR MANGROVE ISLANDS OF THE PELICAN CAYS,
BELIZE**

BY

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**ISSUED BY
NATIONAL MUSEUM OF NATURAL HISTORY
SMITHSONIAN INSTITUTION
WASHINGTON, D.C., U.S.A.
MARCH 2000**

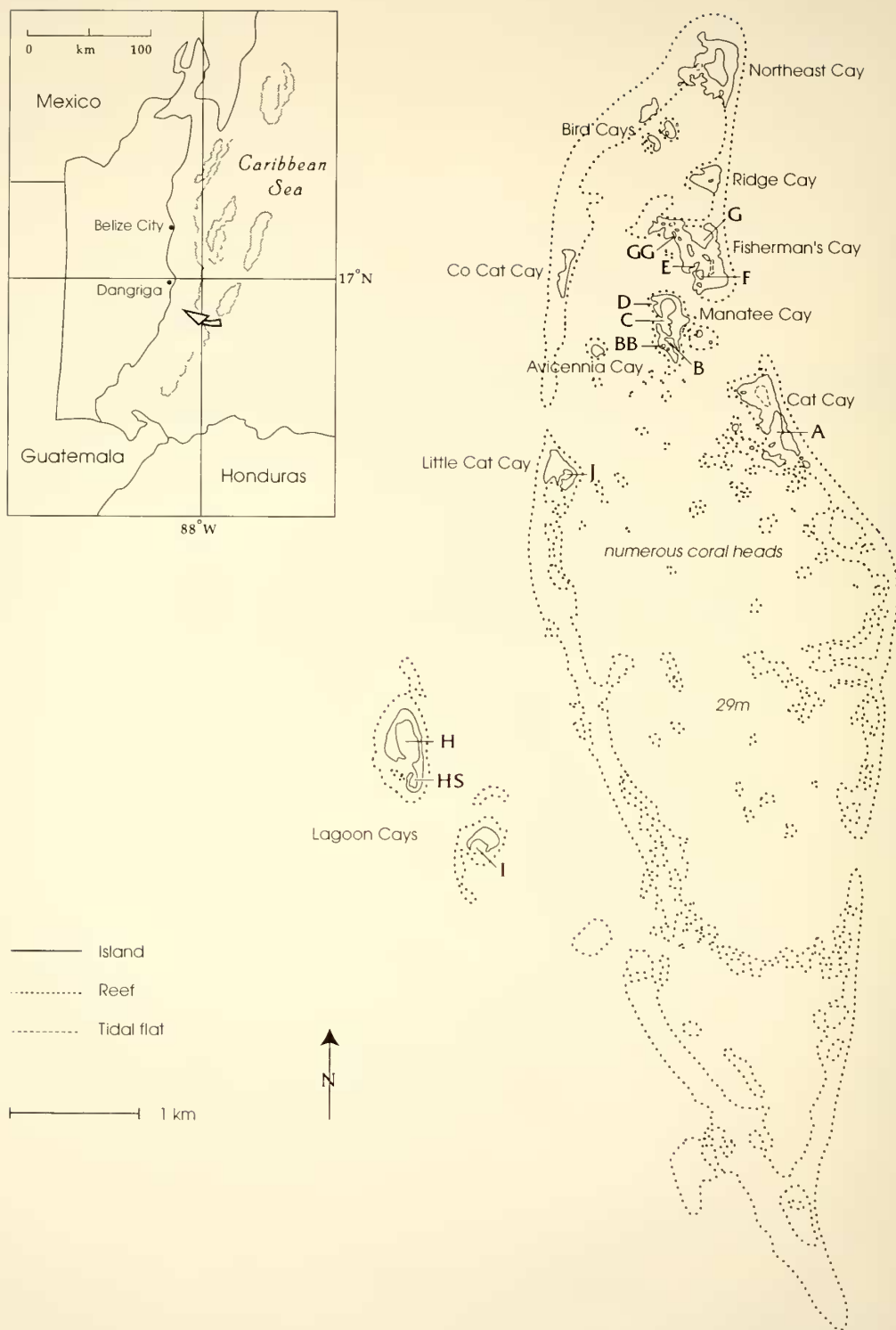


Figure 1. Index map of the Pelican Cays showing the location of the ponds.

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ABSTRACT

A basic description of the geological and biological characteristics of the rims of major ponds in the Pelican Cays is presented. This report is based on a 1994 general survey that was augmented by observations of benthic community populations and systematic collections completed between 1992 and 1997.

INTRODUCTION

The Pelican Cays (16°39.8'N; 88°11.5'W) are a group of mangrove islands (Fig. 1) forming the northwestern section of the Rhomboid Shoals in the southern lagoon of the Belize Barrier Reef complex (Macintyre and Aronson, 1997). These islands occur on elongate shelf atolls with parallel flanks, whose pattern of formation has been controlled by the underlying tectonics of the region (Purdy, 1974a, 1974b). A striking feature of the cays is their distinct circular ponds, which are the result of differential coral and mangrove growth on a Pleistocene subsurface exhibiting a karst polygonal ring pattern (Macintyre et al., this volume). The Pelican Cays ponds constitute pristine, low-energy, benign, and biologically diverse ecosystems dominated by sessile photosynthetic and filter-feeding populations (Littler and Littler, 1997). Most of the marine species are morphologically delicate and vulnerable to damage from the emissions of boat exhausts; physical disturbances by boat wakes, snorkelers, storms, and sedimentation; and natural (Lapointe et al., 1993) and anthropogenic (Littler et al., 1993) eutrophication.

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METHODS

In June 1994, some members of our group conducted a general survey of the geological and biological characteristics of the rims of the Pelican Cays ponds (Fig. 1). Others in the group collected biological information on these ponds at various periods. Maps were drawn from low-altitude, oblique aerial photographs superimposed on existing nautical charts. Coordinates were confirmed by a hand-held GPS (Garman GP545, 15- to 100-m accuracy), and depth soundings were taken using a hand-held Scubapro PDS-2 dive sonar and were converted from feet to meters.

Between February 1992 and August 1997, samples of pond organisms were systematically collected from mangrove prop roots, seagrass flats, and shallow reefs ridges, as well as from the deeper slopes of seagrass beds and reef ridges. Detailed qualitative observations of populations were made using transect-A methods (Goodbody, this volume; Littler and Littler, 1997, this volume; and Rützler et al., this volume). Voucher specimens were examined live at the Carrie Bow Cay field station; they were then prepared for microscope study, fixed in 10% formalin-seawater, and preserved in 70% ethyl alcohol. Sections of the plant materials were made by hand (in the field) or by freezing microtome (in the laboratory). Sections were stained with 1% aniline blue and mounted using a 20% glucose syrup (Karo Syrup, Corn Products, Inc.) solution in distilled water containing a trace of phenol. Sponges were sectioned by hand and the sections were dehydrated, cleared, and mounted in Permout (Fisher Scientific Company); preliminary spicule mounts were made after dissolving representative fragments in 5% sodium hypochlorite. Ascidians were relaxed before fixation by adding menthol crystals to the seawater in observation vessels. The specimens from this study are deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C.

In this discussion, the ponds in the Pelican Cays are identified by letters, although some of the ponds have names (Littler and Littler, 1997): Pond A = Cat Cay Bay; Pond B = Cassiopea Cove; Pond C = Tony's Lagoon; Ponds E and F = Frenchy's Ponds; Pond G = Great Pond; Pond GG = B²; and Pond J = Little Cat Bay.

THE SETTING

The Pelican Cays ponds (Fig. 1) have a number of characteristics in common. Each pond has at least one opening to the surrounding seas, and these openings are restricted to various degrees by coral ridges. Each is surrounded in part by mangrove forests composed of the red mangrove *Rhizophora mangle* and sporadic stands of the black mangrove *Avicennia germinans*. These forests have formed an underlying peat substrate, which is usually eroded around the perimeter of the ponds and undercut to expose some of the root system of the forest above; the exposed roots may be referred to as "bank roots," in contrast to the adventitious "hanging roots" that grow down from the canopy into the water below. Bank roots, hanging roots, the bank rim base, and the exposed peat bank provide substrates for sessile organisms and thus support flourishing communities of sponges, ascidians, algae, corals, sabellid polychaetes, molluscs, bryozoans, and other organisms.

Fine organic sediment, derived from the adjacent mangrove forest floor, lies at the base of most pond rims. Observations of the peat margin at ebb tide revealed that a trickle of suspended organic particles often moves across the peat and settles onto the bases of the ponds. These

bottom sediments are so fine that they are easily disturbed by any movement of the water, as indicated by the random movement of a swim fin. The resulting cloud of suspended material eventually settles on and stresses sessile organisms on the mangrove roots or the peat bank. In many locations the base of the rim is composed of *Halimeda* sediments or accumulations of bivalve shells, depending on the communities flourishing on the adjacent roots and peat bank. In addition, coral debris is exposed at the base of many undercut sections of the peat banks. This debris derives mainly from the reef facies on top of the Pleistocene karst polygonal ridges, and with the mangroves is responsible for the formation of these ponds (Macintyre et al., this volume).

Where sediment and light conditions permit, turtle grass, *Thalassia testudinum*, is a common feature on the bottom around the margins of the ponds. In the center of most ponds, the bottom is covered by an organic-rich mud.

THE SURVEY

Each survey began at the pond openings and continued along the coastal rim in a clockwise direction.

Pond A, Cat Cay (Fig. 2)

The western entrance to Pond A is closed by a ridge about 5 m wide across the top; at high tide this ridge crest is only 0.5 to 1.0 m below the surface. The outer slope, which descends to a depth of about 20 m, is covered in large part by a rich growth of *Agaricia tenuifolia* (Plate 1c),⁵ whereas the crest is dominated by *Porites divaricata* and abundant filamentous algae, with small amounts of *Thalassia testudinum*. Down the outer slope, particularly below 3-5 m, the coral cover is interrupted by large reef-like stands of barrel and rope sponges (*Xestospongia muta* (Plate 3b), *Iotrochota birotulata*, and *Amphimedon compressa*). On the inner side, the ridge slopes down to at least 14 m in the pond. This inner slope too has rich growths of *A. tenuifolia*, with a few stands of *Acropora cervicornis*, which in 1994 were partly affected by white-band disease. The *Agaricia* blades are inhabited by large populations of solitary ascidians (Goodbody, this volume) and sponges, particularly the photosynthetic symbiotic *Ulosa funicularis* (Plate 3a) (Rützler et al., this volume). The colonies of *A. tenuifolia* are delicately balanced on this slope and are easily disturbed. When swimmers just brush by them, the colonies can become dislodged and roll down a talus slope toward the bottom of the pond. Here and there, the colonies have been stabilized by large clusters of *Zoanthus* sp. and encrusting sponges (*Chondrilla* cf. *nucula*) (Plate 3a), which have grown between adjacent coral colonies, bound them together and, in the case of *Chondrilla*, overgrown live coral surfaces. These closely packed plates of coral colonies also provide a cryptic environment for colonial ascidians, sponges, and other sessile organisms. The depth at the center of this pond is 11 meters.

⁵Most of this outer slope population experienced bleaching and subsequently died after long exposure to warm stagnant waters that lasted from August to November, 1998 (Aronson et al. in press).

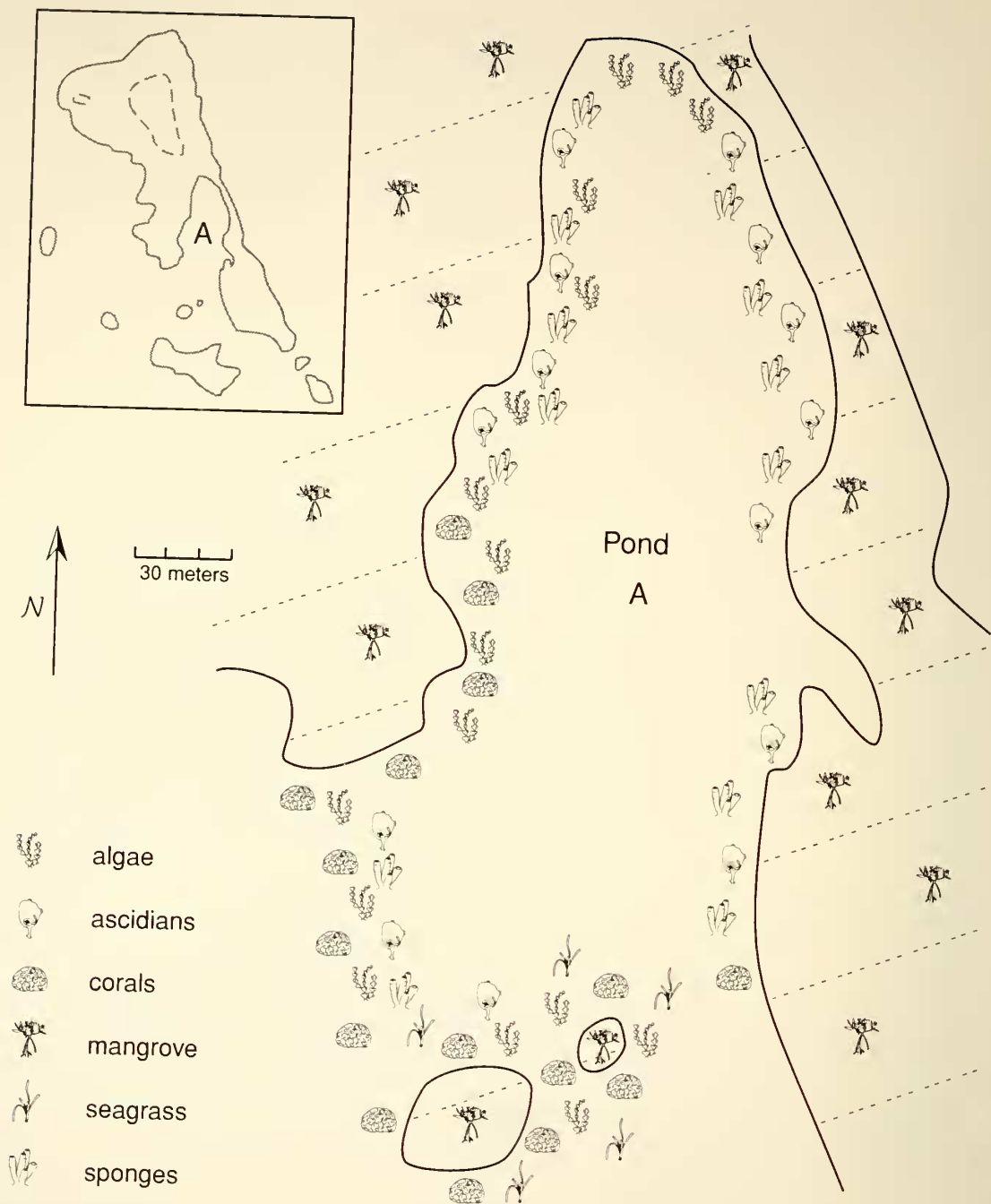


Figure 2. Schematic map showing the distribution of dominant bottom communities around the rim of Pond A

Starting from this western entrance and moving around the pond in a clockwise direction, corals (primarily *Porites divaricata* and *Agaricia tenuifolia*) and algae dominate the rim, flourishing between and around the mangrove roots for about one-third of the way along the western rim to a point where the mangroves become undercut and expose a coral-rubble base composed mostly of *Porites divaricata*, *Acropora cervicornis*, and *Millepora* sp. With a slight increase in depth, this coral rubble gives way to a muddy *Thalassia testudinum* bottom. From this point on, bank roots, hanging roots, and exposed peat banks on the western rim have an abundant cover of sponges and ascidians, with some bryozoans and hydrozoans and a few anemones (*Lebrunea* sp.). The dominant algae are the red *Coelothrix irregularis*, *Acanthophora spicifera*, and *Spyridia filamentosa*; the brown *Lobophora variegata*, *Dictyota* spp., and *Padina sanctae-crucis*; and the green *Caulerpa racemosa*, *C. sertularioides*, *C. mexicana*, *C. verticillata*, *Halimeda opuntia*, and *Dictyosphaeria cavernosa*. Such robust macroalgal populations are indicative of constant, stable, low-nutrient conditions (Lapointe et al., 1993). Unusual species include foliose fleshy red algae (*Gracilaria*, *Meristiella*), epiphytic crustose corallines, and the large green sand-dwelling alga *Udotea* cf. *occidentalis*.

These sessile communities yielded specimens of the gastropod *Calliostoma* sp. and the flatworm *Pseudoceros crozieri*, both of which are probably predators on these communities. On this western rim, one of the most abundant colonial ascidians is *Cystodytes dellechiaiei*, of which there are at least five color morphs; these colonies live preferentially on the peat bank. Several species of sponges are also common on the western rim, notably *Scopalina ruetzleri* (Plate 3e), *Desmopsamma anchorata* (Plate 3c), *Mycale laevis* (Plate 3c), *Iotrochota birotulata*, *Haliclona manglaris*, and *Mycale laxissima*. *Iotrochota* forms dangling ropes of blackish-green sponge hanging from mangrove roots on the lip of the bank. About two-thirds of the way along this western rim there is a distinct mound of dead *Acropora cervicornis* located a little distance into the pond.

The northern shore is composed of a steep peat bank about 1 m high, with occasional areas of undercutting. Large populations of the anemones *Bartholomea annulata* and *Aiptasia tagetes* occupy the roots and peat bank along this shoreline. Small numbers of the bivalve *Chama macerophylla* are also found on the roots but not in the quantities seen in Pond C. A luxuriant growth of the alga *Lobophora variegata* covers this peat bank, and oysters (*Crassostrea rhizophorae* and *Isognomon alatus*) are attached to the roots. Both sponges and solitary ascidians are sparse along this north bank, but some species of colonial ascidians, notably *Clavelina picta* (Plate 2c) and *Ecteinascidia turbinata* (Plate 2e) are present on hanging roots.

At the center of the northern shoreline the pond is close to the open barrier-reef lagoon on the windward side of the island. The mangroves here are thin, and water flows into the pond across this section of mangrove when wind conditions are strong (the prevailing winds are from the northeast). Simple float tests suggest that this inflow is carried into the center of the western rim of this pond, where some of the richest and most interesting populations of ascidians occur. A small recess, or channel, 42 m long occurs in the northeast corner of the pond and leads into it from among the mangroves. The bottom sediments in the recess are sulfurous, which suggests poor circulation.

Rich populations of algae, ascidians, and sponges are again abundant on roots and the peat bank along the eastern rim of Pond A, but these filter-feeding communities are not as abundant as on the westward rim. The southern tip of this eastern rim is occupied by a large colony of *Montastraea annularis*.

Lying further southeast is a deep channel, and next to it is a thriving coral community surrounding a small mangrove island. Most of this community consists of *Agaricia tenuifolia*, *Porites divaricata*, and *Millepora* sp., with thick growths of *Halimeda* between these colonies. Scattered colonies of *Acropora cervicornis* are also present around this island, along with abundant algae and *Thalassia testudinum* growing between the shallow root system. Notable algae include three markedly different forms of *Codium* spp. along the southwest margin and large populations of the red alga *Hydropuntia cornea* on the shallow flats. An *Agaricia tenuifolia* ridge connects this island westward to a larger mangrove island. Another rich ascidian community flourishes on the mangrove roots of this island. This *Agaricia*-dominated community continues westward, connecting with the shallow ridge across the pond mouth.

Pond B, Manatee Cay (Fig. 3)

The entrance to this small pond faces northeast into the direction of the prevailing winds. It is a shallow, muddy pond with a few corals and octocorals at the entrance, which was partly blocked by a shallow flat with two small islands of *Rhizophora mangle*. The outer, northern margin of these islets has several large populations of the agar-producing red algae *Gracilaria cervicornis*, *G. mammillaris*, and *Hydropuntia cornea*.

The rim of this pond has a curtain of hanging mangrove roots covered by algae and ascidians, including *Botrylloides nigrum*, *Polyclinum constellatum*, and *Perophora regina*; the latter two species have not been recorded in quantity from any other ponds in the Pelican Cays (see Goodbody, this volume). The peat bank around the rim of this pond shows little undercutting, and the bottom is covered with fine sediment, which supports abundant populations of several morphological forms of the large jellyfish *Cassiopea xamachana*. The brown crown conch *Melongena melongena* is also common. Ulvlean algae, which indicate eutrophication, are present along the eastern rim. In the southern section, particularly just inside of the entrance, *Thalassia testudinum* flourishes on the mud bottom, giving way to *Syringodium filiforme* in the northern part of the pond. Both of these seagrasses have exceptionally long blades (> 1 m).

Pond BB, Manatee Cay

A small, almost circular pond (about 100 m in diameter) is located southwest of Manatee Cay at 16°39.92'N; 88°11.54'W. A narrow entrance measuring about 20 m across occurs on the western side of the pond. Cutting across the entrance is a ridge with well-developed relief. The crest of this ridge is formed of coral rubble with an abundance of *Thalassia testudinum* and some *Zoanthus* sp.; various large anemones are also present, including *Stoichactis helianthus* and a bright green *Actinostella flosculifera* partly buried in the sediments. Octocorals, most notably *Briareum* sp., are scattered across the ridge along with a few solitary ascidians; *Polycarpa aurita* and *Ascidia sydneinsis* were recorded during a visit in April 1996. The surrounding sediments contain numerous large burrows, suggesting the presence of stomatopods or calianassids. Just south of the entrance is a spectacular population of the giant paddle-like green alga *Avrainvillea asarifolia* (with blades measuring 30 cm by 20 cm).

Inside the lagoon, the entire rim is surrounded by a curtain of hanging roots. The pond floor here is about 1.5 m deep and slopes down to the center of the pond at an angle of about 45°. Much of the peat bank is eroded, exposing a vertical surface about 1 m high. The bottom of this

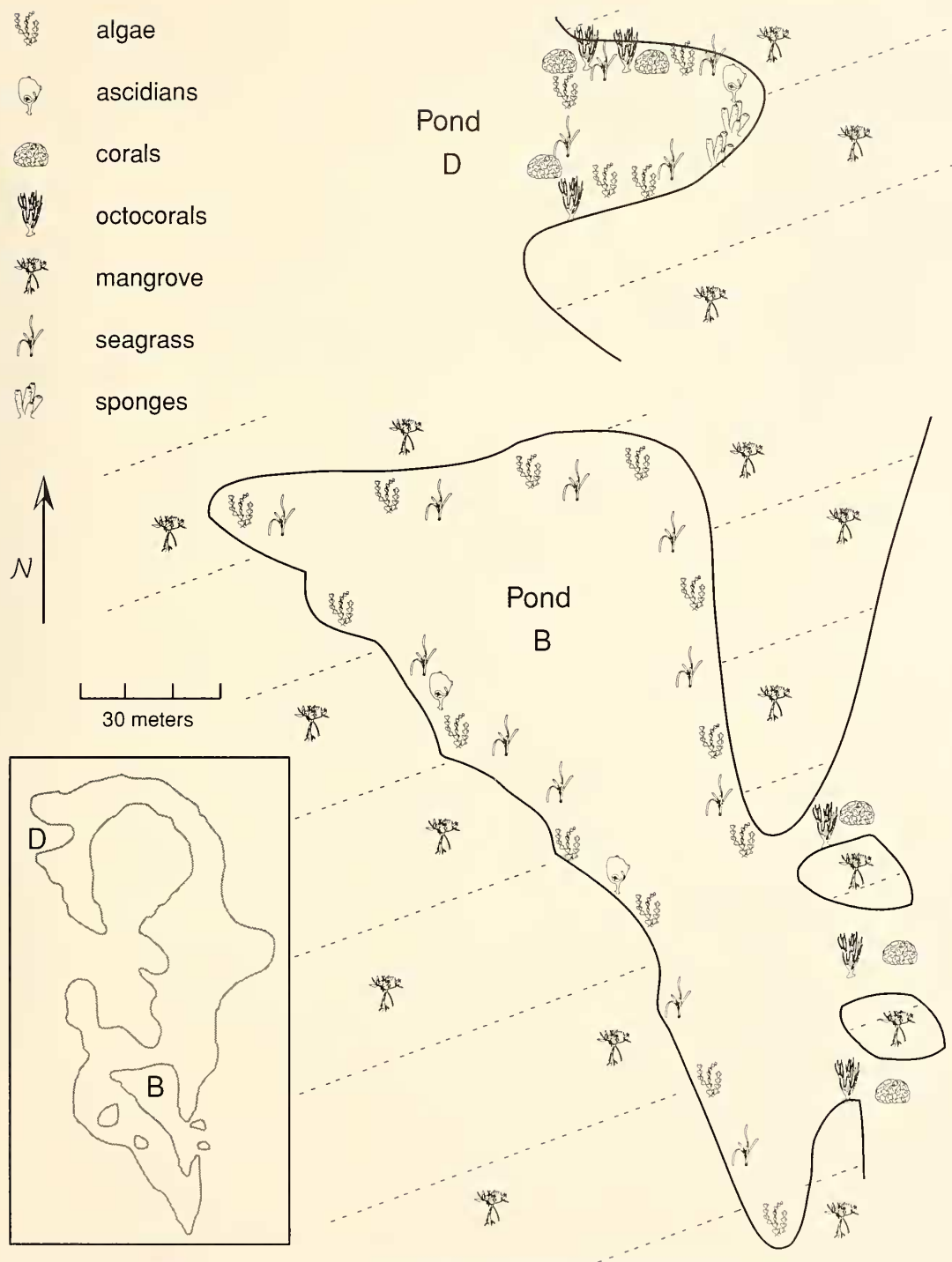


Figure 3. Schematic map showing the distribution of dominant bottom communities around the rims of Pond B and Pond D.

pond consists of fine sediments that are easily resuspended, and the water is generally murky because of suspended particles. Large schools of small harengulid fish inhabit the area, each attended by a barracuda, and apparently play a role in keeping sediments in suspension. No such schools were observed in the other ponds, except for Pond I and occasionally Pond A. Numerous grey (*Lutjanus griseus*) and schoolmaster (*Lutjanus adopus*) snappers can be seen among the roots around the rim of Pond BB.

Sessile communities on the roots here are dominated by sabellids, with sponges and ascidians also being common. Notable among the ascidians are colonies of *Ecteinascidia turbinata* (Plate 2e), also found only in Ponds A and C, and *Didemnum psammathodes*, also observed only in Ponds B and GG. Some roots are populated by clusters of oysters, *Isognomon alatus* and *Crassostrea rhizophorae*, but no barnacles are present. The feathery green alga *Bryopsis plumose* is particularly robust (at 15 cm in length), while the hanging roots are dominated by an interesting form of the giant-celled green alga *Caulerpa nummularia* (a new record for the Caribbean).

Pond C, Manatee Cay (Fig. 4)

Pond C has by far the most spectacular array of plants and multilayered community of filter-feeding animals in the Pelican Cays, including a great variety of algae, colorful tunicates, sponges, tube worms, bryozoans, bivalves, anemones, corals, and brittle stars. The inside of this pond is teeming with juvenile fish and large tarpon (*Megalops atlanticus*).

A ridge stretches across the mouth of this pond. For the most part, the crest is less than 0.5 m deep and about 5 m wide and is covered by corals—*Porites divaricata*, *Millepora alcicornis*, and some *Agaricia tenuifolia*—interspersed with the seagrass *Thalassia testudinum*. The outer flank consists of a rich cover of *A. tenuifolia* (Plate 1c), with lesser amounts of *P. divaricata*, *M. alcicornis*, and *Acropora cervicornis*. In marked contrast, the inner flank (Plate 1d) is dominated by macroalgae, mostly *Halimeda opuntia* along with some *Caulerpa* and *Dictyota*. Sponges such as *Anthosigmella varians* and *Lissodendoryx colombiensis*, with a rich variety of brittle stars, are abundant. Some scattered colonies of corals occur along with octocorals and zoanthids. The north and south ends of this ridge are inhabited by large populations of the red agariphyte *Gracilaria mammillaris*; several other commercially valuable *Gracilaria* spp. are also present.

From the north end of the pond mouth and along the interior rim, the bottom of the pond is covered mainly by *Halimeda*, *Thalassia*, and *Caulerpa*. A solitary coral, *Scolymia lacera*, was found at a depth of 1 m attached to a fragment of *P. divaricata*; this species normally lives in depths of 14 to 40 m in Belize (Cairns, 1982). The *Halimeda-Thalassia* bottom has a rich cover of macroalgae where a coral-rubble ridge meets the western rim. Beyond this area, the mangroves are undercut and the exposed roots support a high diversity of solitary and colonial ascidians and sponges, with many brittle stars and platytenid ctenophores. Sponges cover the hanging roots as well as bank roots and peat surfaces deep into the undercuts, where there is not enough light for algal competitors. Common massive species include *Spongia tubulifera* (Plate 3d), *Scopalina ruetzleri* (Plate 3e), *Mycale laevis* (Plate 3c), *Iotrochota birotulata*, and species of *Ircinia* and *Xestospongia*; encrusting forms appearing in abundance are *Mycale microsigmatosa*, *Clathria venosa*, *Spirastrella mollis*, and *Terpios manglaris*. Examination of this area of the rim at night revealed an abundance of tentacular structures hanging down into the water; these

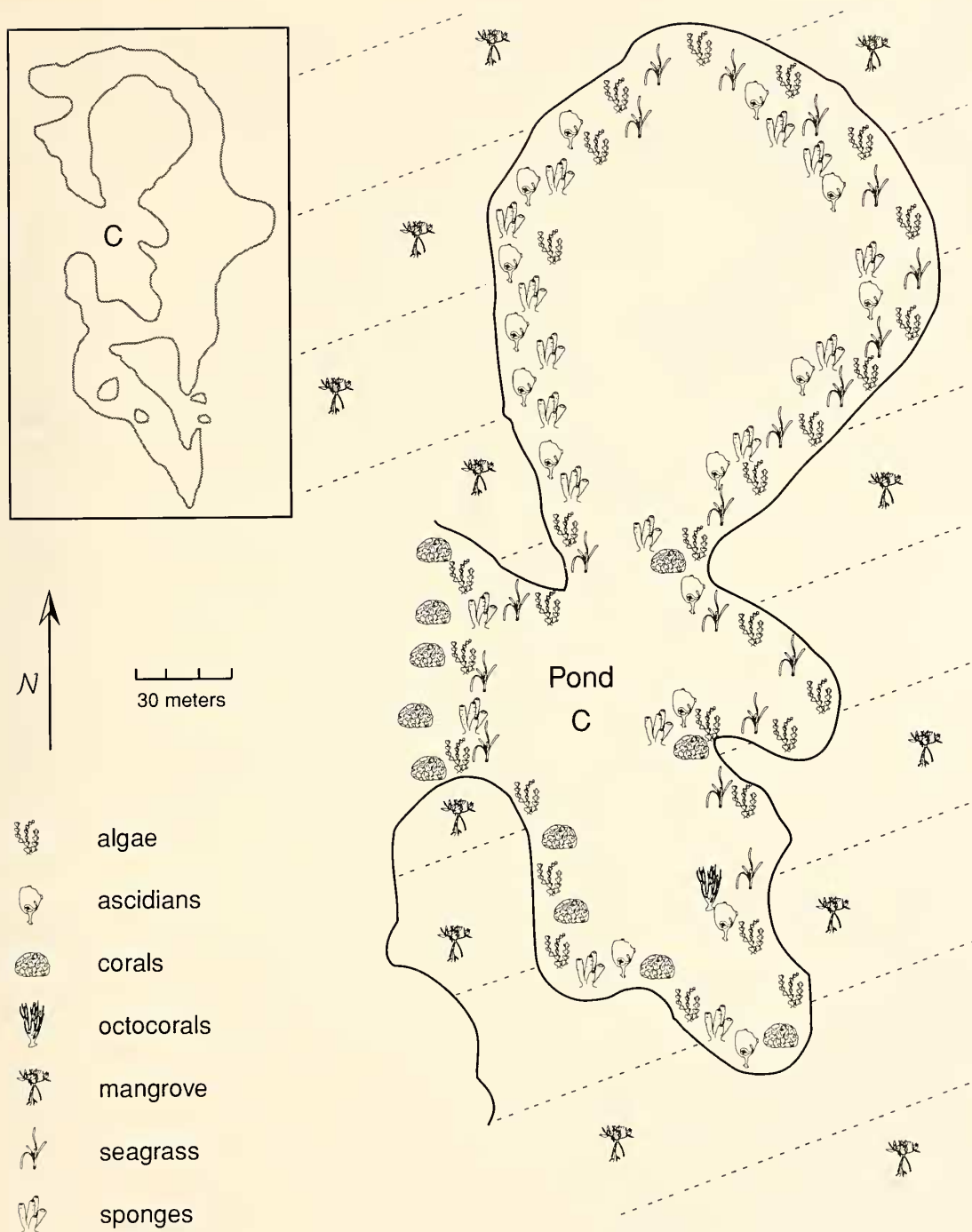


Figure 4. Schematic map showing the distribution of dominant bottom communities around the rim of Pond C.

include the feeding tentacles of platyctenid ctenophores and terebellid worms, as well as the arms of various brittle stars. The base of the undercuts consists of coral and molluscan debris in varying amounts of a matrix of mud; this debris provides a hard substrate for abundant growths of solitary ascidians, especially *Ascidia nigra* and *Polycarpa spongiabilis*. Much of the molluscan debris comes from bivalves, chiefly *Chama macerophylla*, which is abundant on the mangrove root system above.

Toward the northern end of this pond, the bottom becomes muddier, with molluscan debris scattered here and there and an occasional bottom-dwelling jellyfish (*Cassiopea xamachana*). In the northwest corner of the pond the peat bank is undercut by about 1.5 to 2.0 m, leaving a lip 0.5-m thick hanging over the pond floor 1.5 to 2.0 m below. This deep undercut is about 20 m long and provides a substrate for many species of ascidians, sponges, and algae. Toward the center of this lip there is a luxuriant growth of the alga *Caulerpa cupressoides*. Curtains of roots hang on either side of the undercut and are heavily encrusted with sponges and ascidians, notably the colonial ascidian *Diplosoma glandulosum*. At this point on the northern rim of the pond, the mangrove fringe separates the pond from the waters of the open barrier-reef lagoon by a distance of only 16 m, allowing the prevailing trade wind to push water into the pond.

A hanging population of extremely large *Avrainvillea digitata* appears at the intertidal level of the northern margin. Nearby, on the rim base to the east, gigantic *Penicillus pyriformis* lives among the blades of *Thalassia testudinum*. The entire northern rim of Pond C is inhabited by a delicate long-lived community that has experienced little human disturbance, most likely because the shallow ridge across the mouth restricts access and the embayment is so large. This northern section of Pond C is 11 m deep at its center.

Mangroves along the eastern rim of the pond are not as deeply undercut and *Thalassia testudinum* covers a muddy bottom, with only scattered ascidians and sponges found on the mangrove roots. Further south, at a point opposite from the opening, two ridges extend across the pond. These ridges consist of *Porites divaricata* and *Acropora cervicornis* rubble with a *Thalassia* and algal (*Caulerpa racemosa* and *C. cupressoides*) cover. Some live *Porites divaricata* was observed at this location on the eastern rim, along with a variety of ascidians, sponges, macroalgae, and *Thalassia*.

Continuing into the southern embayment, the water reaches a depth of 14 m; the mangroves are not deeply undercut and *Thalassia* covers a muddy bottom. Occasional zooids of the solitary ascidian *Polycarpa spongiabilis* occur among the *Thalassia*, but for the most part the mangrove roots are not heavily encrusted with sessile organisms in this murky embayment, which had a great deal of suspended matter in the water column when first visited on April 27, 1993.

Further south, a small section of a coral rubble ridge extends into the pond. This ridge consists of *Agaricia* sp., *A. cervicornis*, and *Porites divaricata* debris. *Halimeda* is abundant on the mangrove roots, among scattered ascidians and gorgonian corals. Extending around the southern rim of the pond, the mangroves are undercut, revealing a peat cover intermixed with coral debris. The mangrove roots support thick growths of *Halimeda* along with a few colonies of live *Agaricia* sp. This undercut rim with coral debris at the base and *Halimeda* between the roots continues right up to the mouth of the pond, with increasing amounts of live coral, including *Agaricia* sp. and *Porites divaricata*. In addition, large colonies of the brown encrusting bryozoan *Steginoporella magnilabris* are present on the mangrove roots. This southern end of the

pond has several small embayments in which the mangrove roots support luxuriant growths of sponges and ascidians. The colonial ascidian *Ecteinascidia turbinata* (Plate 2e) is common here but is not found in the remainder of the pond. The anemones *Stoichactis helianthus* and *Condylactis gigantea* are also present here. These southern embayments are shallow and covered with scattered growths of *Thalassia testudinum* resting in fine sediments, as well as several species of algae, including *Penicillus* sp. and *Udotea* sp.

Pond D, Manatee Cay (Fig. 3)

The mouth of this small pond is crossed by a sill consisting of coral rubble with a surface community dominated by *Thalassia testudinum*, *Manicina areolata*, *Porites porites*, *Millepora* sp., *Halimeda* sp., octocorals, and zoanthids. The first section of the north rim consists of open mangrove roots covered with the encrusting octocoral *Briareum* sp. (probably *B. polyanthes*) and algae, with a bottom cover of *Halimeda* sp., *Thalassia testudinum*, and scattered *Manicina areolata*. A large colony of *Siderastrea siderea* inhabits the roots. On the north rim, the mangroves are undercut, their roots covered with encrusting octocorals up to a small inlet, where sponges, anemones (*Aiptasia tagetes*), and oysters (*Crassostrea rhizophorae*) increase in number. At this point hydroids become more abundant and the muddy bottom is covered with *Thalassia testudinum* and *Halimeda*. Further to the east, sponges, anemones, and several species of solitary ascidians become more common on the mangrove roots. Colonial ascidians are absent from this pond. The bottom is an organic-rich mud with continuous cover of *Thalassia testudinum*.

The southern rim is formed of undercut mangroves with sponges and algae (most noticeably *Halimeda* sp. and *Caulerpa* sp.) on the roots, with an increasing number of octocorals toward the pond opening. The bottom consists of mollusc and coral rubble in a mud matrix with a cover of *Thalassia testudinum*. The mangrove roots in this pond are sparsely covered by sessile organisms, the octocoral *Briareum* sp. being the most common colonist. This is surprising in view of the fact that the eastern rim of this pond is very close to the richly diverse western rim of Pond C, where populations of *Chama macerophylla* along with sponges and ascidians are so abundant.

During a visit to this small pond on April 5, 1994, many jellyfish, *Cassiopea xamachana*, were observed, along with numerous large burrows in the bottom sediments that suggested the presence of large crustaceans, either stomatopods or calianassids.

Pond E, Fisherman's Cay (Fig. 5)

The entrance to this pond is a narrow gap in the mangroves in the southwest corner that is just wide enough to for a boat to pass through; a manatee swam out through this channel when the site was visited on April 19, 1994. The ridge at the entrance of this pond is almost 4 m deep at its center, which is greater than the depths of ridges found in the other ponds. This ridge is dominated by *Agaricia tenuifolia*, with some *Porites divaricata* and *Acropora cervicornis*; sponges and *Halimeda* are packed between the colonies. At depths of 0.5 m, the southern crest is populated mainly by *Agaricia tenuifolia*, whereas the shallow northern crest consists of a sandy bottom with *Thalassia testudinum* and scattered colonies of *Manicina areolata*, *Millepora* sp., *Montastraea annularis*, *Porites astreoides*, and zoanthids. Octocorals grow around the mangrove roots, along with a light cover of hydroids. The roots here are undercut, and the exposed peat has

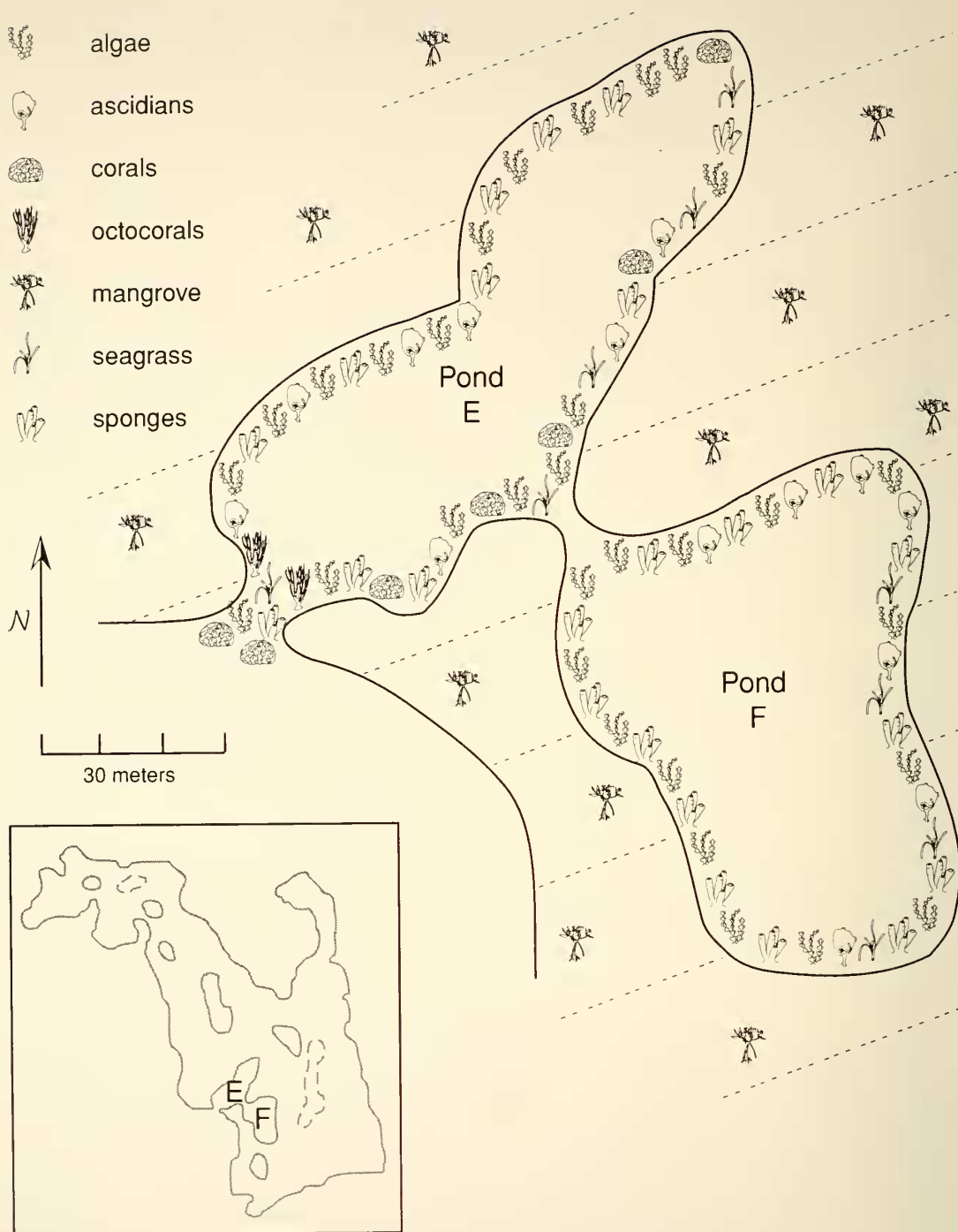


Figure 5. Schematic map showing the distribution of dominant bottom communities around the rims of Pond E and Pond F.

a dense cover of the brown alga *Lobophora variegata*.

Inside this pond and almost around the entire northwest rim, the peat bank is eroded; the vertical face has a relief of about 1.5 m and exhibits relatively little undercutting. This bank provides a substrate for many species of ascidians and sponges. Sponges include many large branching clusters of *Aplysina fulva* and *Artemisina melana*, massive *Scopalina ruetzleri* (Plate 3e), *Mycale laevis* (Plate 3c), and *Spongia* spp., and encrusting *Chondrilla* cf. *nucula* (Plate 3a) and *Mycale microsigmatosa*. Immediately inside the entrance and extending along the northwestern rim, there is a diverse community of ascidians, especially *Clavelina picta* (Plate 2c) on hanging roots, with *C. puertosecensis* (Plate 2d) being more common on the peat bank. Dense growths of green algae are also present, notably *Caulerpa verticillata* on the bank and *C. racemosa* on roots, with *Halimeda* sp. packed between the root system. The latter contributes a considerable amount of carbonate sand to the pond floor, which is inhabited by several species of solitary ascidians, notably *Ascidia interrupta*, *Polycarpa spongiabilis*, and *Microcosmus exasperatus* (Plate 2f). Approaching the north end of this pond, *Halimeda* sp. between the roots remains thick, but other algae are also present, including *Ventricaria ventricosa*. The roots here are covered with numerous sponges, the encrusting bryozoans *Trematooecia aviculifer* and *Stylopoma* sp., hydrozoans, and the brown alga *Lobophora variegata*. A narrow pass at this northern end of Pond E forms a channel into a very small pond. This pass has coral-rubble walls (branching *Porites* sp.) with a *Thalassia testudinum*-covered bottom, which supports a large colony of *Siderastrea siderea*.

The relatively rare ascidian *Halocynthia microspinosa* was seen on two occasions on the peat bank in this pond. Sabellids, probably a species of *Branchiomma*, are also common. Bivalves, on the other hand, are not common, but small numbers of *Isognomon alatus*, *Crassostrea rhizophorae*, and *Chama macerophylla* occur on roots, and a single specimen of *Modiolus americanus* was found in the peat bank on the eastern rim in April 1994. Also at that time, a species of *Atrina* was common in bottom sediments. Numerous large burrows in the sediments indicate the presence of either stomatopods or callianassids.

The southeast rim has noticeably more hydrozoans and corals than the northwest rim. The mangrove roots opposite the pond opening are encrusted by large populations of ascidians, sponges, and *Lobophora* sp., while *Dictyota* sp. and *Porites divaricata* occur between the roots. The *Thalassia*/*Halimeda* muddy bottom contains a considerable amount of branching coral debris. Some colonies of *Montastraea annularis* appear close the opening into Pond F, but most of them are dead and extensively bored by *Cliona* sp. sponges. Algal growth becomes very abundant, with *Halimeda* sp. now found growing on the mangrove roots. A large dead colony of *Siderastrea siderea* along with some live colonies of *Porites divaricata* occurs between the roots.

Continuing past the entrance into Pond F, the bottom is covered by *Porites divaricata* debris along with some live material. The mangrove roots are encrusted with *Lobophora variegata*, sponges, ascidians, and some octocorals, which become very abundant among the roots near the mouth of this pond. The pond is 11 m deep at its center.

Pond F, Fisherman's Cay (Fig. 5)

A shallow opening on the southeastern rim of Pond E forms the entrance to Pond F. The bottom here consists of branching coral that creates a ridge across the entrance. A dead and extensively bored colony of *Montastraea annularis* is present in this pass, and sponges,

Millepora alcicornis, and *Halimeda* sp. are attached to the mangrove roots.

The northern rim is characterized by large quantities of *Halimeda opuntia*, intermixed with the ascidian *Perophora carpenaria*. Sponges (*Scopalina ruetzleri* (Plate 3e), *Aplysina fulva*) are also common. Continuing on to the eastern rim, one finds a very rich *Thalassia/Halimeda* muddy bottom with patches of *Halimeda* sand. Sponges, ascidians, *Halimeda* sp., and some bryozoans flourish on the mangrove roots. All of the mangroves in this pond are undercut.

The southern end of this pond has ascidians, sponges, and *Halimeda* sp. on the roots and the exposed peat wall is covered with *Halimeda* sp. and shingle-like growths of the brown alga *Lobophora variegata* along with a few bryozoans. The bottom consists of a muddy *Halimeda* sand with abundant branching coral rubble. The southwestern rim is dominated by large curtains of the microscopic red alga *Ceramium* sp. on both hanging and bank roots. Other noteworthy algal populations consist of draped masses of *Halimeda opuntia* suspended from mangrove prop roots and mound-like colonies of *Avrainvillea asarifolia*, often overgrown by creeping strands of *Caulerpa* spp.

Sponges are particularly abundant on the undercut mangrove roots of the western rim. Oysters, which are common on the roots of Ponds F, are abundant in this southern rim area, along with some *Halimeda* sp. on the peat banks. Branching coral rubble has accumulated at the base of the undercut and some coral is embedded in the peat. The bottom continues to be a *Halimeda* sandy mud.

The fauna of this pond is similar to that found on the northwestern rim of Pond E. *Scopalina ruetzleri* (Plate 3e) is the dominant sponge, and solitary species of ascidian are common, notably *Pyura lignosa*, *Polycarpa spongiabilis*, and *Ascidia interrupta*. *Clavelina picta* (Plate 2c) and *C. puertosecensis* (Plate 2d) are common all around the rim, along with small colonies of the ascidians *Distaplia corolla* and *Eudistoma olivaceum*. Many species of bivalve molluscs inhabit this pond, including, *Chama macerophylla*, *Brachidontes domingensis*, *Arca inubricata*, *Codakia orbicularis*, and *Spodilyus circus*. During an April 1994 visit, many specimens of the jellyfish *Cassiopeia xanachana* were observed on the bottom of this pond.

Pond G. Fisherman's Cay

This is a large horseshoe-shaped bay at the northern end of Fisherman's Cay. It has a wide opening facing north, which is crossed by a shallow coral rubble ridge with an abundance of *Thalassia testudinum* containing zooids of the ascidians *Polycarpa spongiabilis* and *Herdmania momus* and scattered coral heads. Islets of *Rhizophora mangle* are established along the western edge of this ridge. Noteworthy features are abundant standing crops of commercial agariphytes, such as *Gracilaria cervicornis*, *G. mammillaris*, *Meristiella gelidium*, and *M. echinocarpum*, along the northwestern (outer) border of the lagoon among isolated colonies of the fire coral *Millepora complanata*. *Ulva rigida* blades are prevalent on nearby islet roots directly beneath a seabird roosting site. Moving clockwise around this pond, immediately inside the entrance in the northeast corner is an eroded peat bank about 1.5 to 2.0 m high with no undercutting. The mangrove fringe at this point is narrow, so the waters of the open barrier-reef lagoon have easy access to the pond. Bank roots are exposed on the peat inside this pond, and there is only a thin fringe of hanging mangrove roots, populated mainly by ascidians and some sponges. These ascidian populations do not exhibit the species richness seen in many other ponds, notably Pond

A and Pond C. Other common components of the sessile community on roots are the bivalves *Chama macerophylla*, *Crassostrea rhizophorae*, and *Ivognomon alatus*; the anemones *Aiptasia tagetes*, *Bartholomea annulata*, and *Stoichactis helianthus*; and the barnacle *Balanus eburneus*.

The eroded peat bank continues around the rim of this pond, but as it approaches the southeastern rim it loses its vertical relief and eventually slopes down at a shallow angle into the pond and becomes heavily pitted. At this point sponges increase in number while the solitary ascidians decrease. *Thalassia testudinum* grows on the bottom around almost the entire rim of the pond, and there are occasional patches of *Halimeda* sp. and other algae. These plants grow on a narrow sediment bottom that slopes steeply toward the center of the pond to a depth of 10 to 12 m. Numerous colonies of the rare ascidian *Pycnoclavella belizeana* inhabit the southern rim. The spongy green alga *Avrainvillea nigricans* forms a sparse aggregation on the shallow peat bank at the southern margin, which is the habitat of gigantic specimens of fan-like *Udotea* cf. *occidentalis* extending in a 10 m-long by 1.0 m-wide strip along the rim base. Further back among the shallow roots is an extensive patch of *A. digitata*. Sessile individuals of *Cassiopea xamachana* are common, and several individuals of the unusual brown crown conch *Melongena melongena* are also present. The predominant macroalgae on the roots are *Acanthophora spicifera* and various forms of *Caulerpa racemosa*. The creeping alga *Coelothrix irregularis* forms dramatic neon-blue colonies on submerged fallen trees. The benthic community just beneath the mangrove roots rests on a bivalve-Halimeda-hash substrate dominated by rhizophytic plants (*Thalassia testudinum* and *Caulerpa racemosa* covered by large mats of *Ceramium* sp., *Caulerpa mexicana*, and *Caulerpa sertularioides*). Dominant on the peat bank among shallow prop roots are the brown alga *Padina gymnospora* and the filamentous green *Caulerpa verticillata*.

Continued circumnavigation of the pond rim in the northwest corner leads to islets of *Rhizophora mangle* established at the western end of the ridge crossing the mouth of the pond. Noteworthy features here are abundant standing crops of commercial agariphytes such as *Gracilaria cervicornis*, *G. mammillaris*, *Meristiella gelidium*, and *M. echinocarpum*, along the northwestern (outer border) of the lagoon among isolated colonies of the fire coral *Millepora complanata*. *Ulva rigida* blades are prevalent on a nearby islet on roots directly beneath a seabird roosting site.

Ponds GG, Fisherman's Cay

This three-pond complex on the western side of Fisherman's Cay, appears to have experienced considerable degradation since earlier observations (1992-93), primarily as a result of sedimentation (stress) and boat damage (physical disturbance) (Littler and Litter, 1997). However, colorful sponges and macroalgae are still prevalent on the mangrove prop roots of both ponds. The western margin is healthy and contains a mangrove root community dominated by gorgonians, anemones, stony corals, and macroalgae such as the shelf-former *Lobophora variegata*. Adjacent is a seagrass bed with numerous Bryopsidales, red and green colored species of *Laurencia*, *Coelothrix irregularis*, and *Ceramium* sp., grading into an *Agaricia tenuifolia* ribbon reef containing an individual barrel sponge *Xestospongia muta* (Plate 3b) that is > 1 m high. The bed drops sharply to a depth of 24 m.

Pond H, North Lagoon Cay

This is a large pond with a central depth of 15 to 20 m. Its broad entrance lies on the south side, just behind a ridge of coral rubble, octocorals, and *Thalassia testudinum*. An eroded peat bank 1.5 to 2.0 m high runs around the entire rim and is only slightly undercut except for areas of the western rim, where it is undercut as much as 2.0 m. Present along most of the rim is a narrow curtain of hanging mangrove roots, and the base has extensive beds of *Thalassia testudinum*.

One of the most striking features of this pond is the abundance of solitary ascidians on roots and on the bank, notably *Ascidia nigra*, *A. interrupts*, and *Microcosmus exasperatus* (Plate 2f). With the exception of *Distaplia corolla*, colonial ascidians were not at all common. The brightly colored species of *Clavelina*, which were so abundant in other ponds, especially Ponds A and C, were not found. Sponges are also sparse, particularly vigorously growing forms such as *Scopalina ruetzleri*, which were also common in other ponds. On the other hand, this is one of the few ponds inhabited by large populations of the barnacle *Balanus eburneus*, which are common along some sections of the rim. Bivalves are also appear on roots and on the peat bank, especially *Chama macerophylla*, *Crassostrea rhizophorae*, *Ostreafions*, and *Isognomon alatus*. Broken fragments of bivalve shells attest to the presence of an unidentified predator on these communities. The tests of some ascidians such as *Ascidia nigra* and *Pyura lignosa*, were found sliced open, probably a result of trunkfish attacks (*Lactophrys* sp.). As in other lagoons, juvenile parrotfish are abundant grazers along the root and bank rims.

Occasional clusters of the anemones *Aiptasia tagetes* and *Bartholomea annulata* occur on the upper surface of the peat bank. Ophiurids are also common on the bank and roots around the rim of this pond. The southeast corner has a deep but narrow side channel. The fauna in this channel appears more diverse than in the main pond and includes a number of the colonial ascidians on roots recorded elsewhere in this pond. Sponges are also abundant in this channel, in contrast to the main pond, where they are scarce. The fact that this small side channel is fairly sheltered may account for the abundance of colonial ascidians and sponges.

Pond I, South Lagoon Cay

This is not so much a pond but a large embayment on the south side of the cay. When visited in April 1993, the bay appeared eutrophic green in color, and it contained large schools of small harengulid fish; the food chain is probably supported by a colony of pelicans nesting in trees in the southeast corner of the bay, which deposits a large supply of fecal material into the water. The roots around this bay have large quantities of the alga *Caulerpa sertularioides*, an abundance of sabellid worms, many barnacles (*Balanus eburneus*), and the bryozoan *Schizoporella* sp. The ascidian fauna is typical of fairly eutrophic conditions and includes *Polyclinum constellatum*, *Symplegma brakenhielmi*, *Ecteinasciditi styeloides*, and *Lissoclinum fragile*. *Ascidia nigra* and *Ecteinascidia turbinata* (Plate 2e), both normally expected to occur in such high-nutrient conditions, are not present.

Pond J, Little Cat Cay

The entrance to this pond lies on the southern side of Little Cat Cay and sits behind a

shallow coral rubble ridge containing prominent growths of *Thalassia testudinum* along with large growth forms of *Udotea* cf. *occidentalis*. The pond is small, approximately 175 m long, about 100 m across, and not more than 6 m deep; coordinates for this pond are 160°39.13'N; 88°11.96'W. The pond is entirely surrounded by mangrove forest, and the peat banks are extensively undercut in places, especially along the northeastern rim. This undercutting has exposed a system of bank roots, which are shielded around most of the pond by a fringe of hanging roots; shell and coral debris line the pond floor beneath the undercut. As in other ponds, these roots are covered by extensive growths of sessile organisms, especially the solitary ascidians *Pyura lignosa*, *Polycarpa aurita*, *Ascidia interrupta*, *Polycarpa spongiabilis*, and *Microcosmus exasperatus* (Plate 3f), as well as many colonial ascidians, including *Botrylloides nigrum*, *Symplegma brakenhielmi*, *Lissoclinum fragile*, *Diplosoma glandulosum*, and *Perophora carpenaria*. Other common inhabitants of the sessile communities are sponges, small anemones, sabellid worms, and the oyster *Isognomon alatus*. The alga *Caulerpa racemosa* is common on some roots along the western shore of this pond.

Characteristic Communities around Some Cays

Cat Cay South Island (see Littler and Littler, 1997), a small mangrove island just below the mouth of Cat Cay Bay, contains three markedly different growth forms of *Codium* spp. along the southwest margin. Cat Cay South Island is bordered by a narrow grass flat (*Thalassia testudinum*), except for regular intervals of "ribbon reefs" of the leaf coral *Agaricia tenuifolia*, which forms crescents connected at their proximal ends to the mangrove stands. Here the trees and seagrass flats extend as points into the ribbon reefs. Several of these extended flats support large populations of the red alga *Hydropuntia cornea* (which is locally valued as an aphrodisiac when prepared in porridge and is commercially bottled as "Double Trouble Sea Moss" in the Lesser Antilles). These mangrove root systems also contain unusually extensive colonies of stony corals along with abundant macroalgae, sponges, tunicates, and anemones.

Avicennia Cay, a small mangrove island resting on an isolated lagoonal patch reef just to the southwest of Manatee Cay, was surveyed from the reef slope upward to the edge of the mangrove prop roots. The steep outer slope was found to be covered by *Agaricia tenuifolia* leveling off in the shallows to form a gorgonian/seagrass community. A passing manatee was observed in this habitat during May 1995. The north side of the cay is the site of a shallow reef crest formed mainly by the fire coral *Millepora complanata* and the finger coral *Porites porites*.

Behind this crest, shallow seagrass beds adjoin the mangrove treeline. Agariphytes (*Gracilaria cervicornis*, *G. mammillaris*, and *Hydropuntia cornea*) are abundant on the seagrass and mangrove root systems here. The slight embayment on the south end of the cay is sandy and slopes upward to dense stands of *Thalassia testudinum*; the mangrove root systems are not particularly rich, and their algal populations are similar to those on the west side of Steward Cay to the north.

Ridge Cay is surrounded by seagrass beds and is the only site containing the economically important carrageenan producer *Eucheuma isiforme* (also used to make a sea-moss beverage). The eastern-facing (outer) bedded mangrove prop roots are covered with interesting and colorful populations of small epiphytic clumps of seaweeds such as the grape-like *Botryocladia spinulifera*, mesh-like *Anadyomene stellata*, feathery *Bryopsis plumosa*, *Laurencia* spp., *Codium* spp., and encrusting *Peyssonnelia boergesenii*. Some lagoonward hanging roots

support unusually large populations of various *Caulerpa* species and calcareous *Halimeda opuntia*.

Northeast Cay, the northernmost island, contains a substantial fish camp at the western tip and serves as a popular anchorage for sailboats. The small coves southeast of the fish camp contain a community similar to the GG ponds of Fisherman's Cay, but populations are small, and the area is overgrown by curtain-like masses of a colonial *Ceramium* diatom. The mangrove prop roots outside the coves are richer but red-algae are predominant (*Laurencia papillose*, *Digenia simplex*, *Acanthophora spicifera*). Unattended fish traps inside the small coves during May 1995 contained dead and dying French angel fish and gray snapper. The northern margin of this island is especially rich in gorgonian corals (fan and branched forms) and elkhorn coral (*Acropora palmata*) patch reefs, with another developing fish camp conspicuous along the shoreline.

The Bird Cays consist of three islands, the westernmost of which has an algal community similar to that of Co Cat Cay and Little Cat Cay to the south (described below). The northeastern and southeastern Bird Cays are located in the atoll-like lagoon and are surrounded by narrow seagrass flats that drop from an *Agaricia* margin to steep sediment-strewn slopes. Both of these islands contain bird roosting sites; ulvalean green algae associated with eutrophication are present but minimal. Populations at Co Cat Cay and Little Cat Cay, the two westernmost cays in the Pelican Cays group, are not particularly noteworthy except for their algal floras, which resemble those of the western cays of Blue Ground Range and Stewart Cay to the north. The eastern borders of each are composed of narrow strips of seagrass beds (*Thalassia testudinum*) that slope steeply into the lagoon with scattered heads of the branched fire coral *Millepora complanata* and the massive starlet coral *Siderastrea siderea* at the upper margins. The mangrove-root epiphytes are heavily laden with sediment and consist of various *Galaxaura* spp., *Acanthophora spicifera*, and *Lobophora variegata*. The western borders are richer and more interesting, with broad shallow seagrass flats containing large fan and whip gorgonians, *Millepora complanata*, *Montastraea annularis*, and *Porites* heads. The roots are rich in *Anadyomene stellata*, *Lobophora variegata*, *Gracilaria mammillaris*, *Bryopsis plumose*, and many *Caulerpa* spp., along with anemones and corals. The southern portion outside the entrance to Pond J is especially rich in seaweeds such as *Codium* sp. and *Hydropuntia* sp. of impressive size.

The mangrove prop roots on the western tip of Little Cat Cay are heavily epiphytized by the weedy red alga *Acanthophora spicifera*. The outer (eastern) margin of the reef at the southeast tip of Cat Cay, just at the start of Five Mile Flat (see Littler and Littler, 1997) where it adjoins the island, was surveyed down to depths of 30 m. Below a depth of 26 m, the plan sandy bottom levels off and gradually slopes to deeper depths. From depths of 20 to 26 m, the bottom consists of sand-inundated rubble with sparse biota. From depths of 20 to 8 m, *Halimeda* spp. and *Lobophora variegata* are abundant. From depths of 8 m and upward, sponges, bryozoans, and the green macroalgae *Penicillus pyriformis*, *Halimeda* spp., *Udotea* spp., and the brown *L. variegata* are predominant among the *Agaricia tenuifolia* that flourishes between 3 and 15 m. Many calcareous algae such as *Peyssonnelia boergesenii*, *Jania adherence*, crustose Corallinaceae, and *Amphiroa* spp. are present on the dead skeletons of *A. tenuifolia*. In depths of less than 7 m, the seagrass *Thalassia testudinum*, large gorgonians (whips and fans), and corals such as *Porites porites*, *P. astreoides*, and *Millepora complanata* are prominent.

DISCUSSION

The preceding observations are of a general qualitative nature owing to the lack of good quantitative data on most of the communities. Furthermore, many organisms were difficult to identify accurately in the field. Nevertheless, the survey yielded sufficient information demonstrating that the Pelican Cays ponds are of considerable interest and can contribute greatly to scientific understanding of Caribbean marine sessile communities. A challenge for future studies will be to explain the differences and similarities between the various ponds. For example, the western rim of Pond A is similar in many respects to the northwestern part of Pond C, but both differ markedly from the western and northern rims of Pond H. All three of these ponds are large and are oriented in a north-south direction, so they remain sheltered from the prevailing northeast trade winds. All three ponds, however, show some sign of water replacement at the northern end across the mangrove rim when the tide is high and the trade winds are blowing strongly. Whether this water flow pattern influences the types of communities in the ponds is at present unclear.

Several of the ponds exhibited high levels of species diversity, notably Ponds A, C, and E; this may be associated with the proximity of coral reef communities at the pond entrance. Some other ponds have unique features: Pond D, for example, is populated by octocorals that do not grow to any extent in the other ponds; Pond B has populations of *Perophora regina*, an ascidian otherwise recorded only from Twin Cays and Blue Ground Range further north on the barrier reef platform. Pond BB, which is very close to Pond B and separated from it by only a narrow area of mangrove swamp, lacks *Perophora regina* but has an abundance of another perophorid, *Ecteinascidia turbinata*, otherwise abundant in only in Pond C. *Balanus eburneus*, a large barnacle widely distributed in Caribbean mangrove communities, is only sparsely distributed in the ponds of the Pelican Cays. It occurs in Ponds C, G, H, and L, but not in Ponds A or E. Sponge diversity in the better-studied ponds A, C, E, and F is different in species spectrum from all others mangrove species studied in the Belize lagoon and approaches that of open reefs, although the species composition only partly overlaps that of known reef environments. About 40% of sponge species collected in the Pelican Cays ponds are unusual, aberrant, or undescribed.

In summary, the Pelican Cays represent a spectacular, high-biodiversity, low-energy environment dominated by photosynthetic and filter-feeding populations. Most are physically delicate and highly susceptible to damage from boat wakes, careless swimmers, physical contact (e.g., trampling), sedimentation, and nutrient enrichment. The existence of such high biodiversity in a small geographic area can be attributed to the unique juxtaposition of mangrove, coral, seagrass, and algal biomes under stable oligotrophic conditions (as indicated by the consistently "gin-clear" waters). Few of the ephemeral sheetlike and filamentous green algae indicative of eutrophic bird islands (e.g., Man-of war Cay, Douglas Cay) or anthropogenically polluted systems (see Littler and Littler, 1997) are present. A long-term study of the trophic structure of the Pelican Cays ponds could shed some light on the factors controlling the distribution of organisms within them.

ACKNOWLEDGMENTS

Special recognition is due to Paul Shave of Wee Wee Cay who first introduced us to the Pelican Cays by showing us Pond A in 1992. That visit marked the beginning of our studies in this area. Tony Rath brought to our attention Pond C and provided some excellent aerial photographs of the ponds. Very special thanks to Victoria E. Macintyre Saville, Michael R. Carpenter, and Bruno Pernet for field assistance. We are also grateful to William T. Boykins and Molly K. Ryan for valuable help with graphics and design; Barrett L. Brooks for support during botanical work; and Charlotte Goodbody for assistance in the preparation of this manuscript. Funding for the botanical research was provided by NSF Grant DEB-9400534, Harbor Branch Oceanographic Institution, and the Smithsonian Marine Station, Fort Pierce, Florida. Fieldwork for this survey was supported by the National Museum of Natural History's Caribbean Coral Reef Ecosystem Program (CCRE Contribution No. 577).

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APPENDIX

STATUS OF SCLERACTINIAN CORALS IN SOME PELICAN CAYS PONDS
FOLLOWING THE 1998 BLEACHING EVENT

BY

IAN G. MACINTYRE

On June 11, 13, and 15, 1999, I visited Pelican Cays ponds A, C, D, and E to assess the status of the scleractinian corals following the massive 1998 bleaching and die-off of corals in the surrounding rhomboid shoals (Aronson et al., 2000). Unusually high water temperatures recorded on the shallow reefs during this bleaching killed almost all the agariciid corals in the shoals and the few *Acropora cervicornis* that had survived an earlier outbreak of white-band disease (Aronson and Precht, 1998).

Pond A, Cat Cay

All the *Agaricia tenuifolia* colonies that previously formed a rich cover on both flanks of the ridge across the western entrance of this pond are now dead, as are the associated *Acropora cervicornis*, *Millepora alcicornis*, and most of the *Porites divaricata*. Much of this recently dead coral is already extensively covered by the encrusting sponge *Chondrilla* cf. *nucula*, mats of *Zoanthus* sp., and macroscopic algae, primarily *Halimeda opuntia* (Figs. 1, 2). Only traces of live *Porites divaricata*, *Colpophyllia natans*, and *Porites astreoides* were found on the crest of this ridge (Fig. 3a,b).

No live corals were found along the western rim north of this entrance. The once lush growths of *Agaricia tenuifolia* and *Porites divaricata* around the red mangrove stilt roots are dead and overgrown by sponges, zoanthids, and macro-algae (Fig. 4).

The other coral area in Pond A occurs at the southern end, where coral communities once formed a rich cover around the small mangrove island and along the ridge connecting this island to the western entrance ridge. All *Agaricia tenuifolia*, *Porites divaricata*, *Millepora* sp., and *Acropora cervicornis* reported in our original survey are dead and covered with an expansive growth of sponges and macro-algae such as *Halimeda opuntia* and *Caulerpa racemosa* and clumps of blue-green algal filaments (Fig. 5).

Pond C, Manatee Cay

Here, too, the spectacular growths of *Agaricia tenuifolia* with some *Porites divaricata*, *Millepora alcicornis*, and *Acropora cervicornis* that covered the outer slope of the ridge across the western entrance are dead and partly covered by the encrusting sponge *Chondrilla* cf. *nucula* (Fig. 6). The inner slope has an even denser cover of *C. cf. nucula*, *Zoanthus* sp., and *Halimeda opuntia* over coral rubble. The crest supports a few live colonies of *P. divaricata* being encroached upon by zoanthid mats and encrusting sponges (Fig. 7).

A quick check for the live *P. divaricata* reported on the eastern rim opposite the entrance

revealed only dead colonies, still in growth position and encrusted by *C. cf. nucula*. However, a few small live colonies of *Porites astreoides* were found attached to mangrove roots.

On the southern rim, only traces of live *P. divaricata* and *P. astreoides* were found, now overgrown by vigorous colonies of *Zoanthus* sp. (Fig. 8).

Pond D, Manatee Cay

The *Thalassia*-covered low ridge across the western entrance to this pond still supports healthy colonies of *Manicina aerolata* (Fig. 9) and *Porites divaricata*.

Along the north rim, *P. divaricata* is struggling to survive an overgrowth of zoanthids, *Halimeda opuntia*, and anemones (Fig. 10). The large *Siderastraea siderea* colony earlier reported on this north rim is still alive but clearly competing with zoanthid mats, encrusting *C. cf. nucula*, and algal growth (Fig. 11). High turbidity inside this pond impeded observations.

Pond E, Fisherman's Cay

The shallow north end of the ridge across the entrance to this pond still supports live colonies of *Porites divaricata* (Fig. 12a) and *Manicina aerolata* on a sandy *Thalassia*-covered bottom. By contrast, the deeper southern crest, which was originally covered by a flourishing coral community dominated by *Agaricia tenuifolia*, has no live corals. Most of the dead colonies are still in growth position and are encrusted by the sponge *Chondrilla cf. nucula* and overgrown by *Halimeda opuntia* (Fig. 12b).

Small live colonies of *P. divaricata* on peat banks and *P. astreoides* on mangrove roots were found on both the southern and eastern rims. The large colony of *Siderastraea siderea* previously reported from the north end of the pond is still flourishing there.

DISCUSSION

Though brief, the visits to Ponds A, C, D, and E in 1999 revealed that the 1998 bleaching event caused major changes in the benthic communities of the Pelican Cays ponds. There has been a drastic loss of coral cover, with only a few scattered live colonies of hardier species surviving, including *Porites divaricata*, *P. astreoides*, *Colpophyllia natans*, *Siderastraea siderea*, and *Montastraea annularis*. The most vulnerable corals have been *Agaricia tenuifolia*, *Acropora cervicornis*, and the hydrocoral *Millepora alcicornis*: no live colonies of these species were found in the ponds or on the outer flanks of ridges across the entrances.

Sponges, colonial zoanthids, and algae have benefited from this demise of the corals and are flourishing on the recently dead skeletons. Some are even growing over the coral remnants that are still alive. Among the sponges, the encrusting *Chondrilla cf. nucula* is the most noticeably abundant organism, accompanied by extensive mats of *Zoanthus* sp. and heavy growths of the green algae *Halimeda opuntia* and *Caulerpa racemosa*.

More detailed observations planned for the near future will document this change more accurately and possibly provide a sense of the long-term trends in the species composition of the benthic communities of the Pelican Cays ponds.

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Figure 1. Pond A - Cat Cay. Outer flank of ridge across western entrance. Dead *Agaricia tenuifolia* extensively encrusted by *Chondrilla* cf. *nucula* and surrounded by growths of *Halimeda opuntia*. Scale = 20 cm. June 13, 1999.



Figure 2. Pond A - Cat Cay. Inner flank of ridge across western entrance. Very extensive cover of encrusting sponge *Chondrilla* cf. *nucula* over coral rubble. Note scattered growths of *Halimeda opuntia* and abundance of brittle stars (arrows). Scale = 20 cm. June 13, 1999.

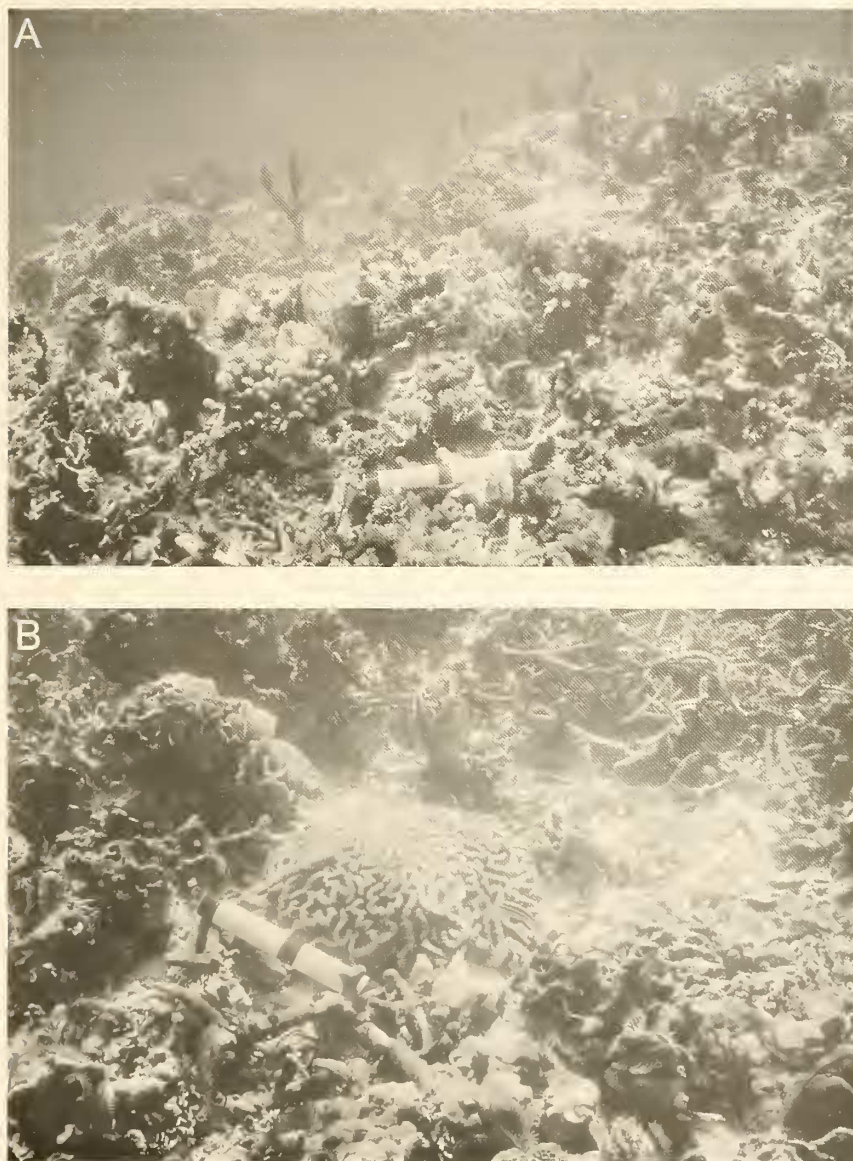


Figure 3. Pond A - Cat Cay. Crest of ridge across western entrance. A) Patches of live *Porites divaricata* on a bottom consisting of dead coral encrusted by *Chondrilla cf. nucula*. B) Live colony of *Colpophyllia natans* surrounded by dead coral encrusted by *C. cf. nucula* and packed with *Halimeda opuntia*. Scale = 20 cm. June 13, 1999.



Figure 4. Pond A - Cat Cay. Western rim north of the western entrance. Dead *Agaricia tenuifolia* partly covered by *Chondrilla* cf. *nucula*, *Halimeda opuntia*, and mats of colonial *Zoanthus* sp. Scale = 20 cm. June 13, 1999.



Figure 5. Pond A - Cat Cay. Formerly coral-rich area around a small mangrove island at the southern end of this pond. Dead *Agaricia tenuifolia* being overgrown by *Halimeda opuntia* and tufts of filamentous blue-green algae. Scale = 20 cm. June 13, 1999.



Figure 6. Pond C - Manatee Cay. Outer flank of ridge across western entrance. Dead coral bottom -- mostly *Agaricia tenuifolia* with some *Acropora cervicornis* and *Millepora alcicornis*. Patchy encrustations of *Chondrilla* cf. *nucula* (arrows). Scale = 20 cm. June 13, 1999.



Figure 7. Pond C - Manatee Cay. Crest of ridge across western entrance. Live *Porites divaricata* almost smothered by encrusting colonial *Zoanthus* sp. and *Chondrilla* cf. *nucula*. June 15, 1999.

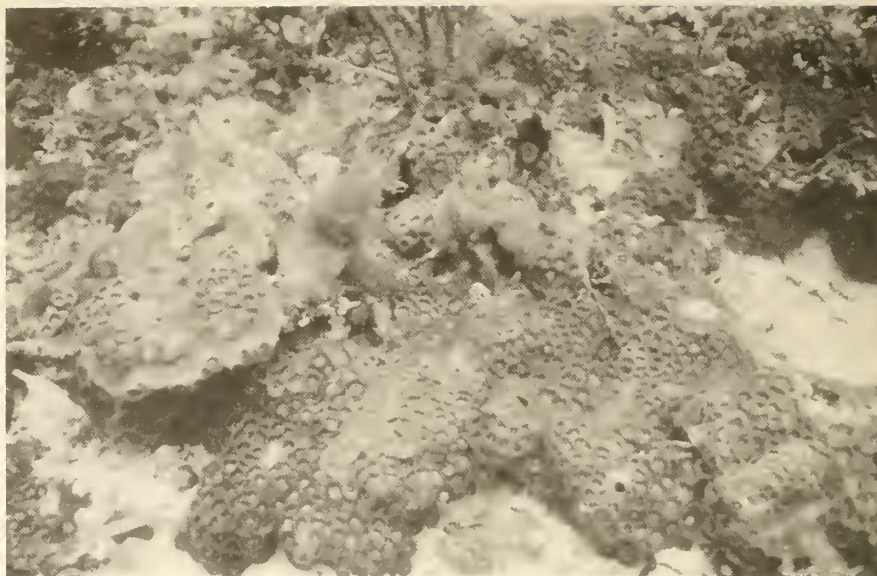


Figure 8. Pond C - Manatee Cay. Southern rim of this pond. Live *Porites astreoides* almost overgrown by colonial *Zoanthus* sp. June 15, 1999.



Figure 9. Pond D - Manatee Cay. Crest at north end of ridge across entrance. Live *Manicina aerolata* (arrows) on a *Thalassia*/coral rubble bottom. June 15, 1999.



Figure 10. Pond D - Manatee Cay. North rim of this pond near the entrance. Tips of live *Porites divaricata* poke up through a cover of colonial *Zoanthus* sp., *Halimeda opuntia*, and an anemone. June 15, 1999.



Figure 11. Pond D - Manatee Cay. North rim of this pond. Large live colony of *Siderastraea siderea* coping with attached *Zoanthus* sp., *Chondrilla* cf. *nucula* (arrow), and macroscopic algae. June 15, 1999.

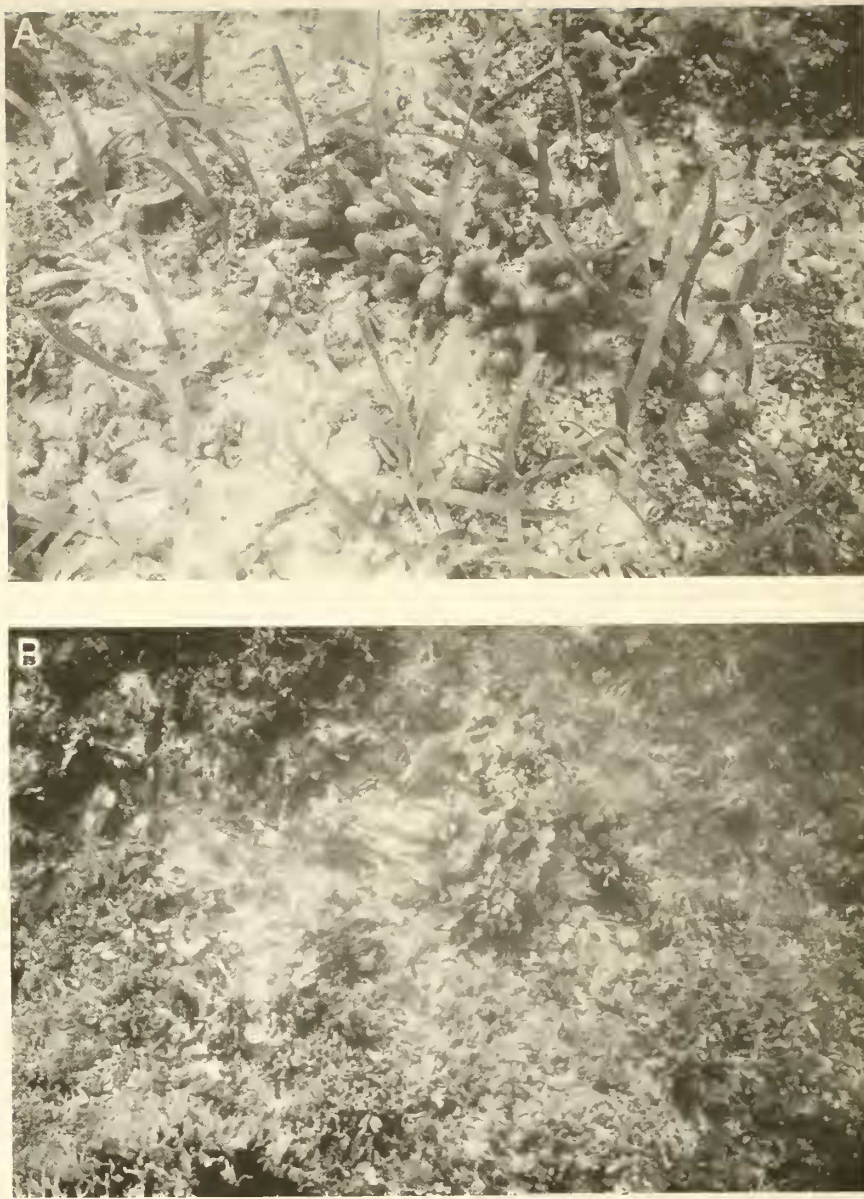


Figure 12. Pond E - Fisherman's Cay. Crest of ridge across entrance. A) Shallow north end of ridge. Live *Porites divaricata* on a *Thalassia/Halimeda* bottom. B) Deeper south end of this ridge. Dead *Agaricia tenuifolia*, mostly in growth position, encrusted by *Chondrilla cf. nucula* and surrounded by *Halimeda opuntia*. June 15, 1999.